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# Scale model study of balcony insertion losses on a building façade with non-parallel line sources

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ABSTRACT

The screening effect of balconies on a building façade in the case where the noise source is not parallel to the façade is studied using scale model experiment in the present study. Results show that the angle of source inclination to the façade has substantial effects on the balcony insertion loss in the presence of a traffic noise spectrum. Less amount of noise amplification is observed when the source is inclined compared to the case of parallel source in the presence of balcony ceiling reflections. Regression formulae in terms of three independent angles which determine the positions of the balcony and its ceiling relative to the noise source are developed for the prediction of balcony insertion loss. The discrepancy between measurements and predictions is within engineering tolerance.



## 1. Introduction

Hong Kong is a very densely populated city. High-rise buildings are very popular in this city and they have to be erected close to ground transportation lines because of the very limited flat lands for both commercial and residential purposes. The traffic volumes along existing roads are also increasing in recent years probably due to the economic growth. Besides, new train lines are constructed to cope with people needs. There are many cases in recent years that noise barriers cannot be built in many developed districts because of problems related to barrier foundation, safety, etc. Green features for buildings have been proposed and incentives have been given to the building developers and architects from the local government [1].

Façade balcony is one form of the green features proposed. Its acoustic protection has attracted the attention of many researchers. For instance, Oldham and his co-workers [2–4], and Hammad and Gibbs [5] studied the insertion loss (*IL*) of a single balcony through scale-down model experiment. There are also numerical studies on the effects of balcony ceiling on the noise levels at the protected façade [6,7]. May [8] studied the effect of acoustic linings on reducing the noise level inside a high-rise balcony well above a nearby freeway.

A recent paper of the author [9] studied the *IL* of façade balconies using scale model experiments conducted in an anechoic chamber. Effects of various common balcony forms were also investigated. Unlike many studies in the existing literature, a balcony array was adopted in the previous study of the author [9] as it is very difficult to find standalone balconies in Hong Kong. It was found that an angle defined using the balcony configuration and the source position correlated well with the *IL* when the line source was parallel to the façade. The front panel of the balcony in such case was found to have played a key role in the noise screening process.

Hong Kong is very congested and the building façades in many cases are not parallel to the major noise producing roads. In the present study, the screening performance of different balcony forms under a non-parallel straight line source is studied experimentally using a scale model. Since there are many parameters which can affect the insertion loss of balconies, such as their dimensions, the present study is focused on effects of non-parallel sources. It is hoped that a preliminary picture on the effectiveness of balconies as screening devices on building façades facing non-parallel transportation lines can be obtained.

## 2. Experimental setup

The test rig and the measurement accessories adopted in Tang [9] are used in the present study. It consists of a physical model with a scale-down ratio of 1:10 made of varnished plywood of negligible sound absorption in the measurement frequency range. Similar scale-down ratio has been adopted by Oldham and Mohsen [3]. Fig. 1 is the schematic drawing of the scale-down model. The horizontal perpendicular distance of the centre of the model façade to the line source made of 54 small loudspeakers, $d$, is fixed at 1 m

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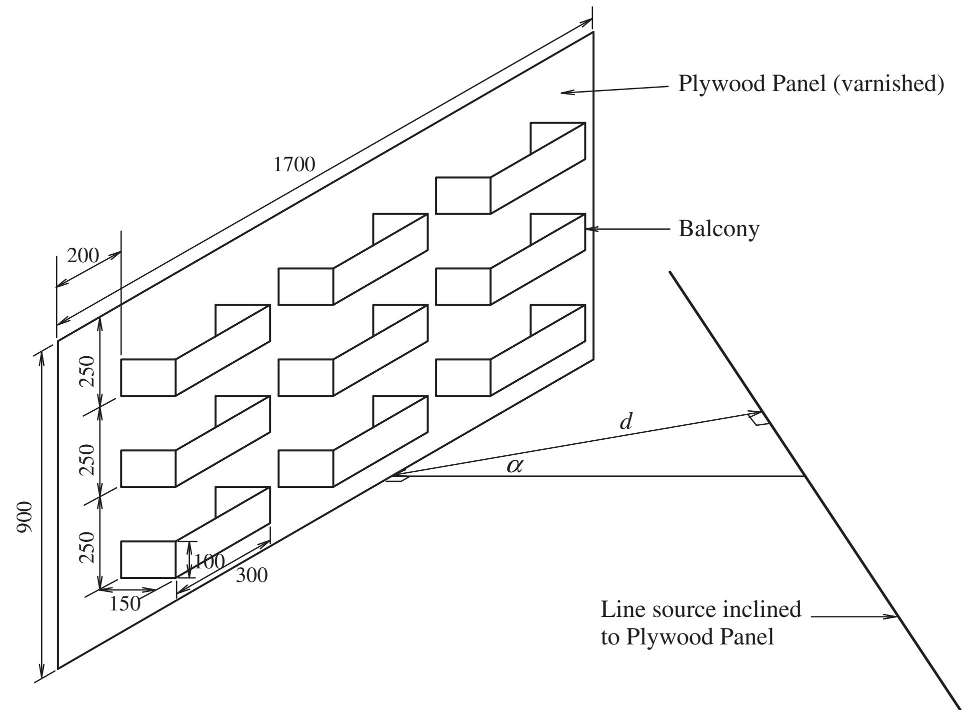


**Fig. 1.** Dimensions of the scale model and nomenclature adopted.

(=10 m in the full scale model), while the azimuthal angle $\alpha$ takes the value of 0, $\pi/6$, $\pi/3$ and $\pi/2$. All the balconies are detachable. The present setup is similar to that employed by Oldham and his co-workers [3,4], except that they used five air jets for the line source simulation, ignored the reflection from the upper balconies and did measurements inside a model room behind the façade. In the present study, there is no model room and the façade is represented by the varnished plywood panel (Fig. 1).

The *IL*s behind the central balcony column are the focus of the present study. There are 25 equi-spaced holes behind each of the central column balconies for fixing quarter inch microphones (Brüel & Kjær 4935) during the sound pressure level measurement (Fig. 2). A DAT recorder with a sampling rate of 48,000 samples per second is used for recording the microphone signals for later processing. Owing to the scale-down ratio, the highest 1/3 octave band represented by the present results is the one with a centre frequency of 2 kHz, which should be satisfactory for traffic noise study [10]. Complete details on the test rig and on the quality of the sound source can be found in Tang [9] and thus are not repeated here. The experiment is performed inside an anechoic chamber of working floor area and height of 4 m by 5 m and 3 m, respectively. The air temperature and the relative humidity inside the chambers are maintained at 22 °C and 50%, respectively.

The four balcony forms investigated in the present study follow those of Tang [9] (Fig. 3). In the present study, both the effects of the source azimuthal angle and the side balconies on the *IL* of the central balcony column are investigated. Fig. 4 illustrates the angles which are expected to be important for correlating with *IL*s.

It should be noted that the *IL* of a façade element is frequency dependent. Since the most common noise source in an urban envi-

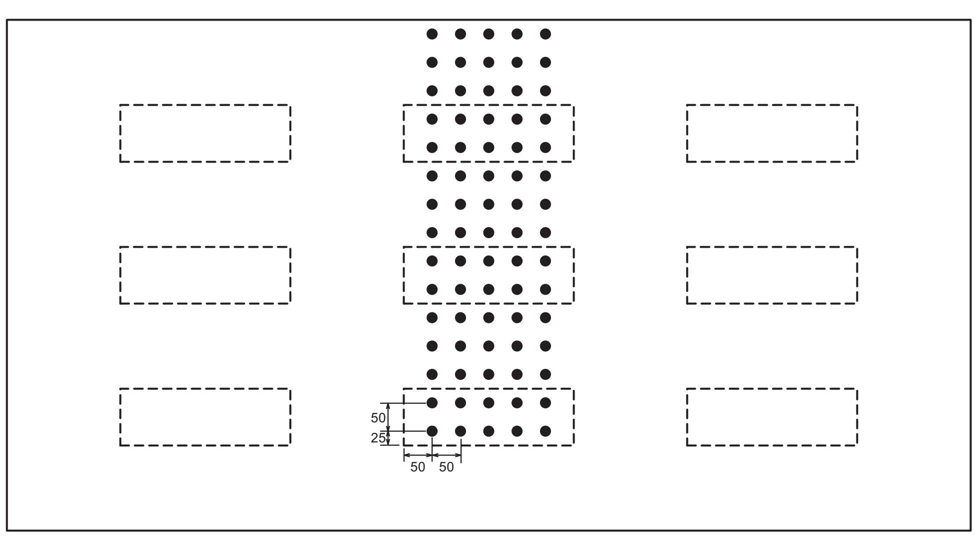


**Fig. 2.** Noise measurement locations. ●: Locations of microphones; — — —: locations of balconies.